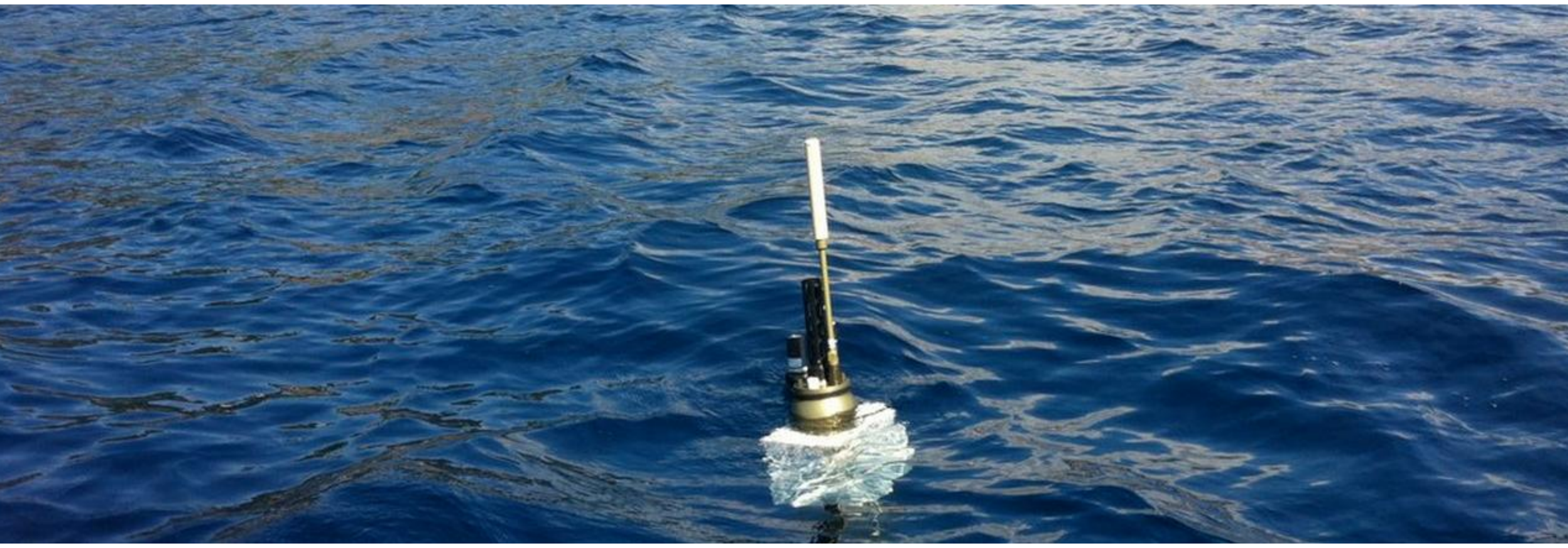
APMT Profiler – Under Ice Capabilities

AUTOMATED **M**ULTI-**T**ASK **P**ROFILER



33-16-056_APMT_Under_Ice_Capabilities
Revision 1.4 (2021-03-08)

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1. Revision history

Revision	Release date	Notes	Author
1.0	2020-01-20	Original	C. SCHAEFFER
1.1	2020-02-25	Adding information about “ice deceleration”	C. SCHAEFFER
1.2	2020-03-16	Modifying “ice sensing algorithm” description	C. SCHAEFFER
1.3	2020-05-13	Adding [ICE_AVOIDANCE].P4 parameter Adding [SYSTEM].P0 parameter	C. SCHAEFFER
1.4	2021-03-08	Adding appendices examples	C. SCHAEFFER

2. Introduction

The use of profiling floats in the polar oceans is seriously impeded by the presence of sea ice as floats are not able to transmit their data. An ice-avoidance algorithm is essential for ice floats.

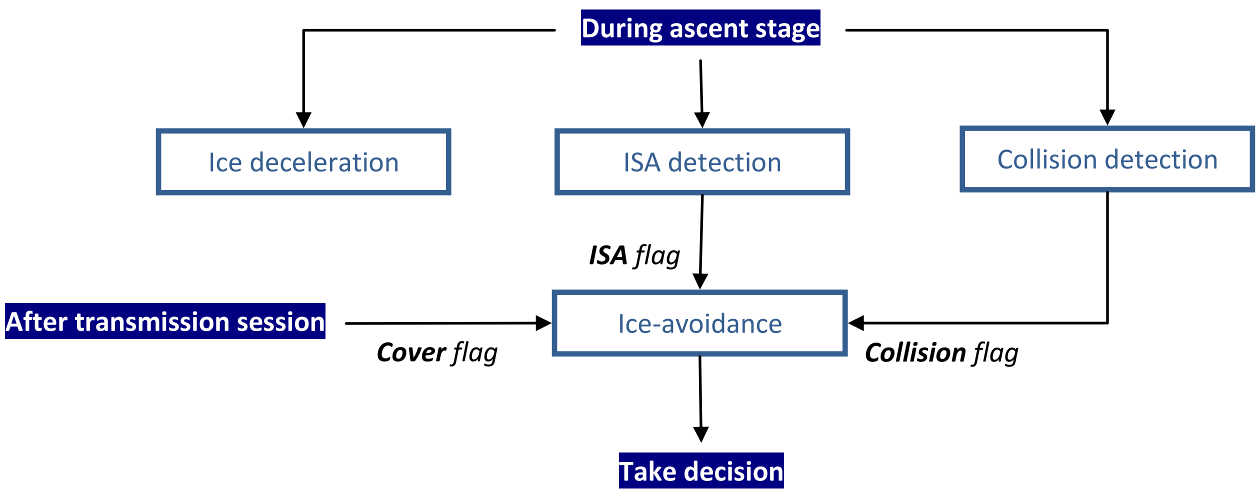
The main objective of ice-avoidance algorithm is to prevent the float from being damaged by knocking the underside of the sea ice or crushing in free-floating ice blocks at sea surface. The second objective is to save energy when surfacing is not efficient.

3. Under-ice features

3.1 Overview

To safely navigate and collect data under the ice, ice floats need specific features compared to floats operating in open waters:

- Reduction of the ascent speed when approaching the surface
- Mechanism for detecting ice cover:
    - Ice-sensing algorithm prediction
    - Hitting the underside of the sea ice
- Evasion mechanism to abort surfacing
- Ability to store and keep in memory important amount of data

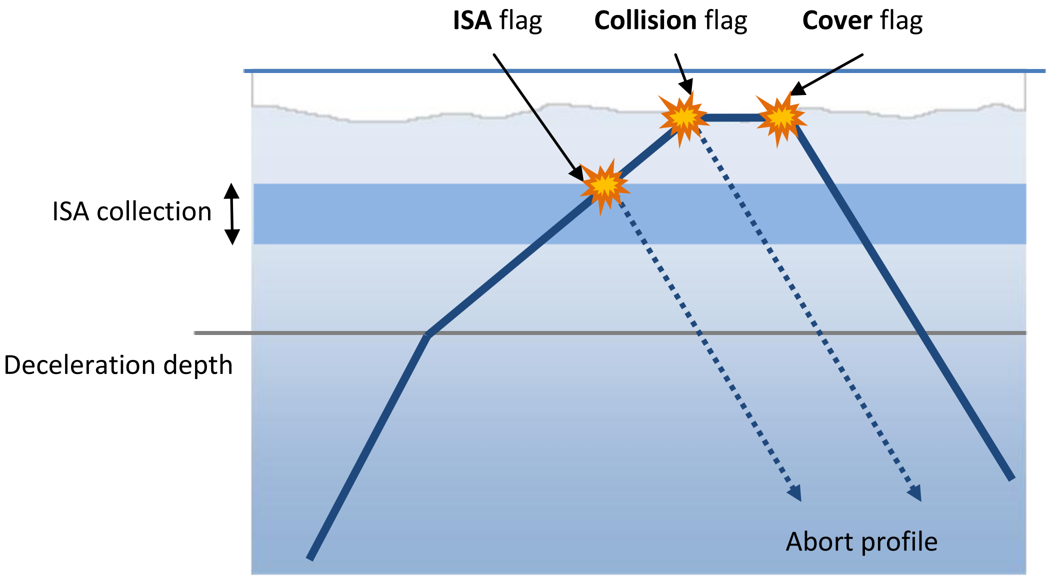


--- Figure 1. Under-ice features ---

The final decision takes into account different states of the float:

- **ISA** flag based on the result of the ice-sensing algorithm
- **Collision** flag if the float is blocked in the underside of the sea ice
- **Cover** flag exploits the Iridium system to determine if the float is at the surface with sky view

When the algorithm takes the decision to abort a profile, technical and sensor data are stored in the memory. The float keeps the data collected into its memory until transmission.



--- Figure 2. Under-ice decision ---

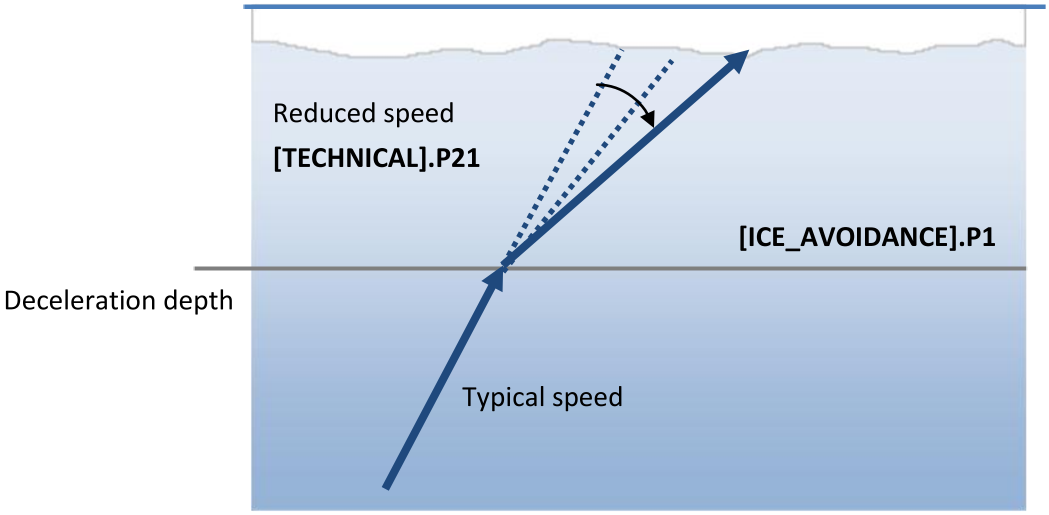
3.2 Ice deceleration

This feature consists in dividing the ascent in different stages in order to allow the float to detect the presence of ice and to abort the profile.

The operation is as follows:

- Stage 1: "Standard" ascent to the deceleration depth
- Stage 2: "Slow" ascent to surface

The “deceleration power” can be adjusted to obtain better results. The more the ascent speed is reduced, the more the ascent stage is extended.



--- Figure 3. Ice deceleration ---

The deceleration power parameter is used to select a set of predefined parameters for ascent speed control. The “0” level selects the user parameters defined in the configuration file.

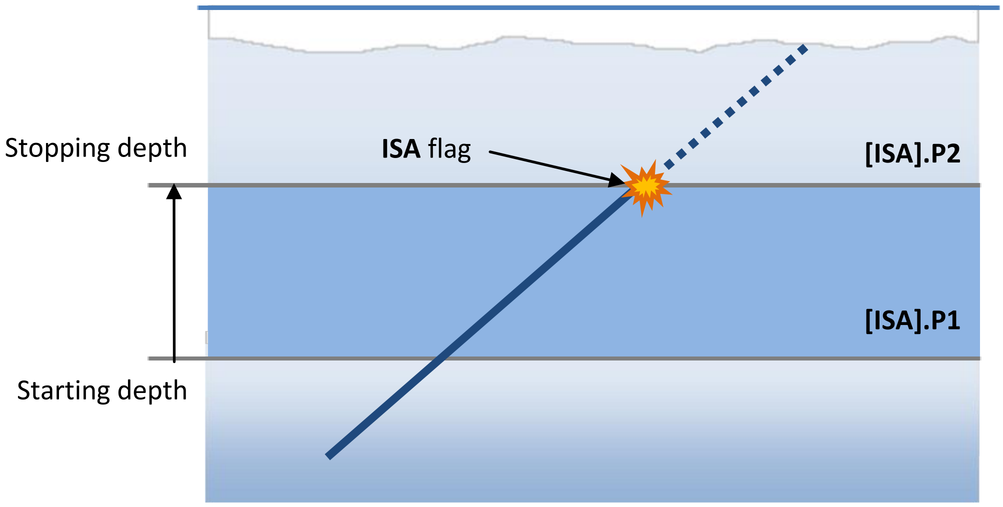
Deceleration power settings				
	Level	**Survey period (s)**	**Speed threshold (cm/s)**	**Pump action (cm3)**
User settings	0	[TECHNICAL].P9	[TECHNICAL].P1	[TECHNICAL].P15
Standard speed settings		120	8.33	15.0
↓	1	220	5.0	7.0
	2	240	4.0	5.5
	3	260	3.0	4.0
	4	280	2.0	2.5
Lowest speed settings	5	300	1.0	1.0

Note: For more details on ascent speed control refer to “33-16-048_Parameter_Set” manual section “Navigation / Ascent”.

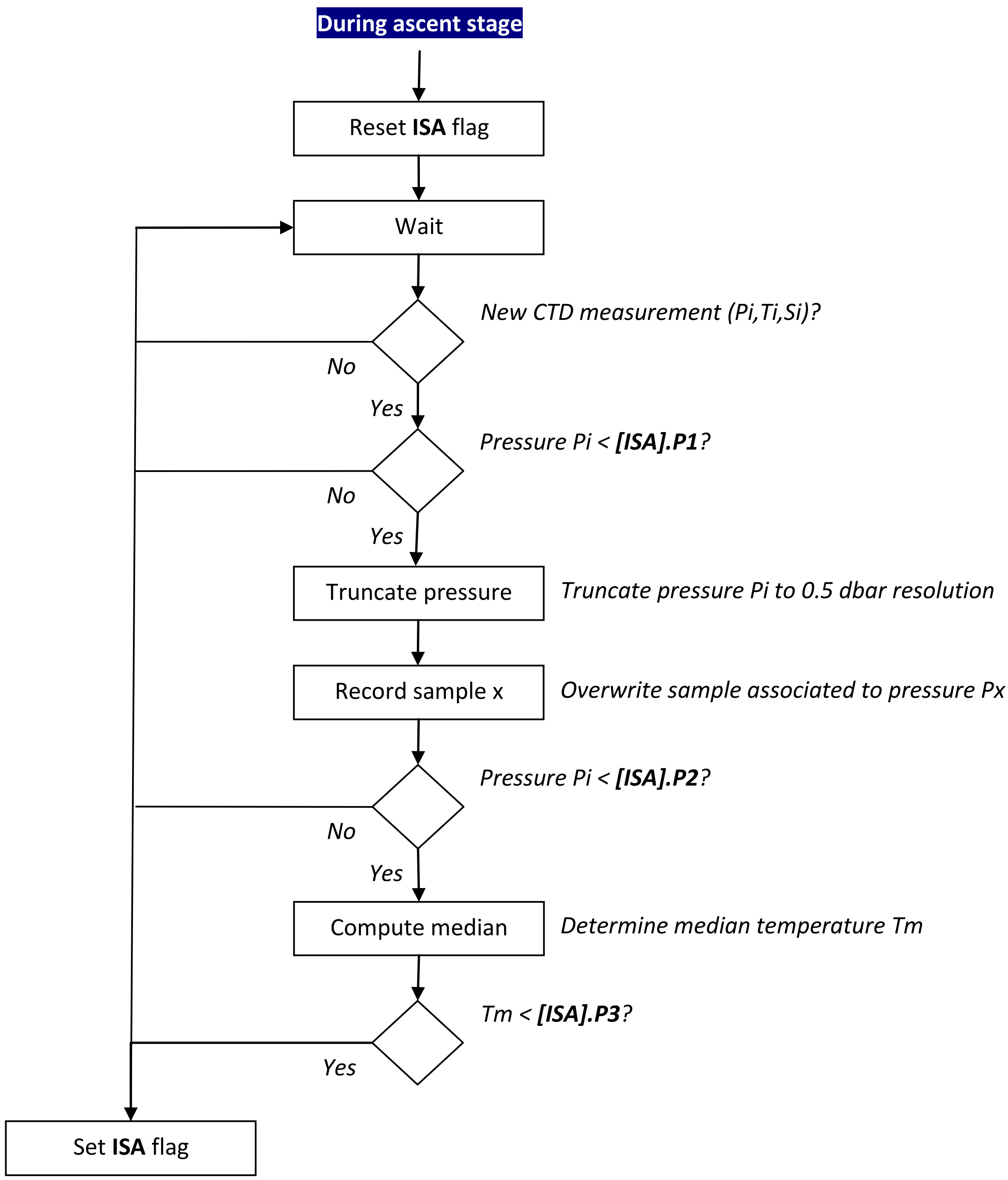
3.3 Detect ice: ice-sensing algorithm (ISA)

This algorithm relates subsurface water temperatures to the probability of sea ice at the surface.

Temperature samples are collected during ascent stage, sorted, and stored every 0.5 dbar. The algorithm calculates the median temperature within a pressure interval close to the surface and compares it with a predefined threshold.



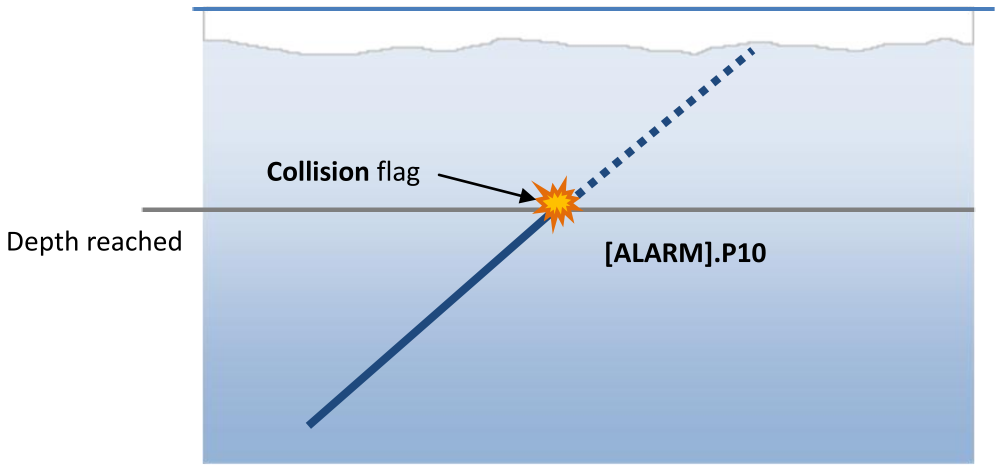
--- Figure 4. Detect ice by ice-sensing algorithm ---



--- Figure 5. Ice-sensing algorithm ---

3.4 Detect ice: hitting the underside of the sea ice

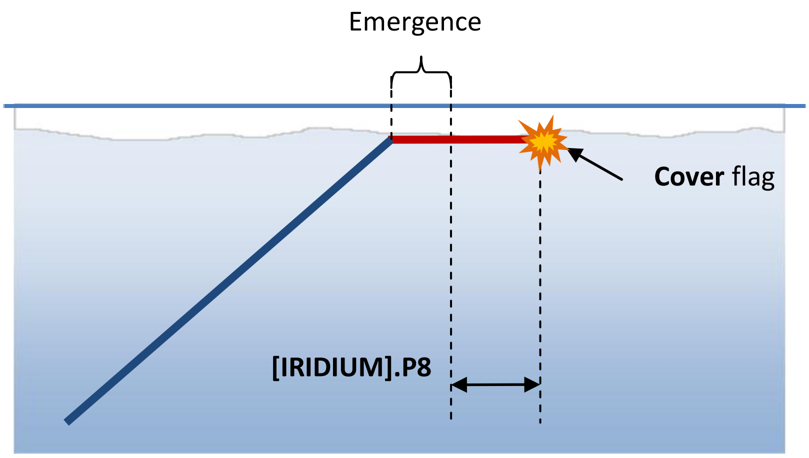
The detection of the underside of the sea ice is made by the collision detection feature of the float. It consists in detecting the absence of movement of the float despite a large displacement of oil to ascend.



--- Figure 6. Detect ice by hitting the underside of the sea ice ---

3.5 Detect ice: no sky view

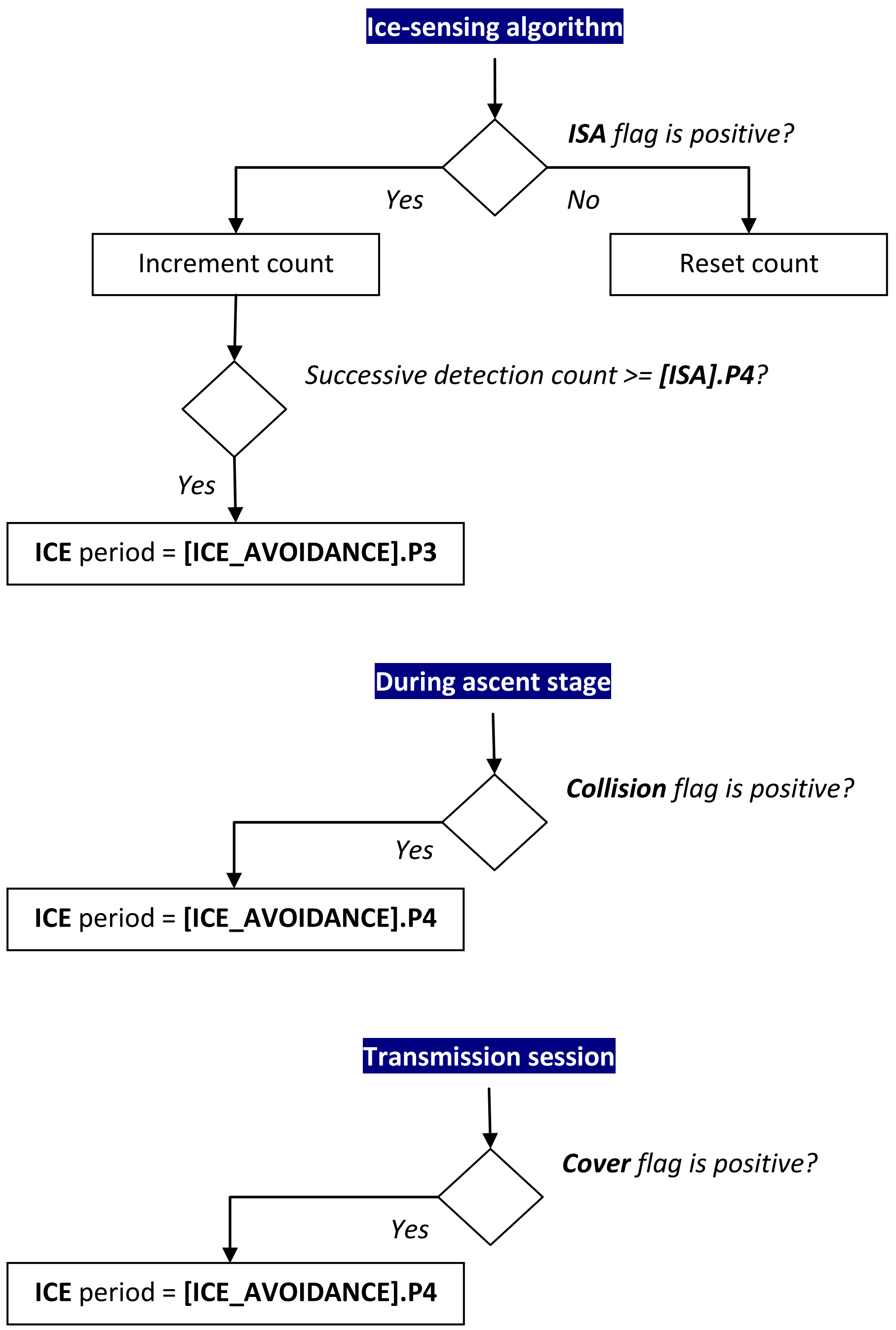
The coverage flag, indicating that the float has no view of the sky, is positioned when the float cannot connect to the satellites or register with the service for a given period of time.



--- Figure 7. Detect ice when no sky view ---

3.6 Detect ice: maintaining period – persistence mechanism

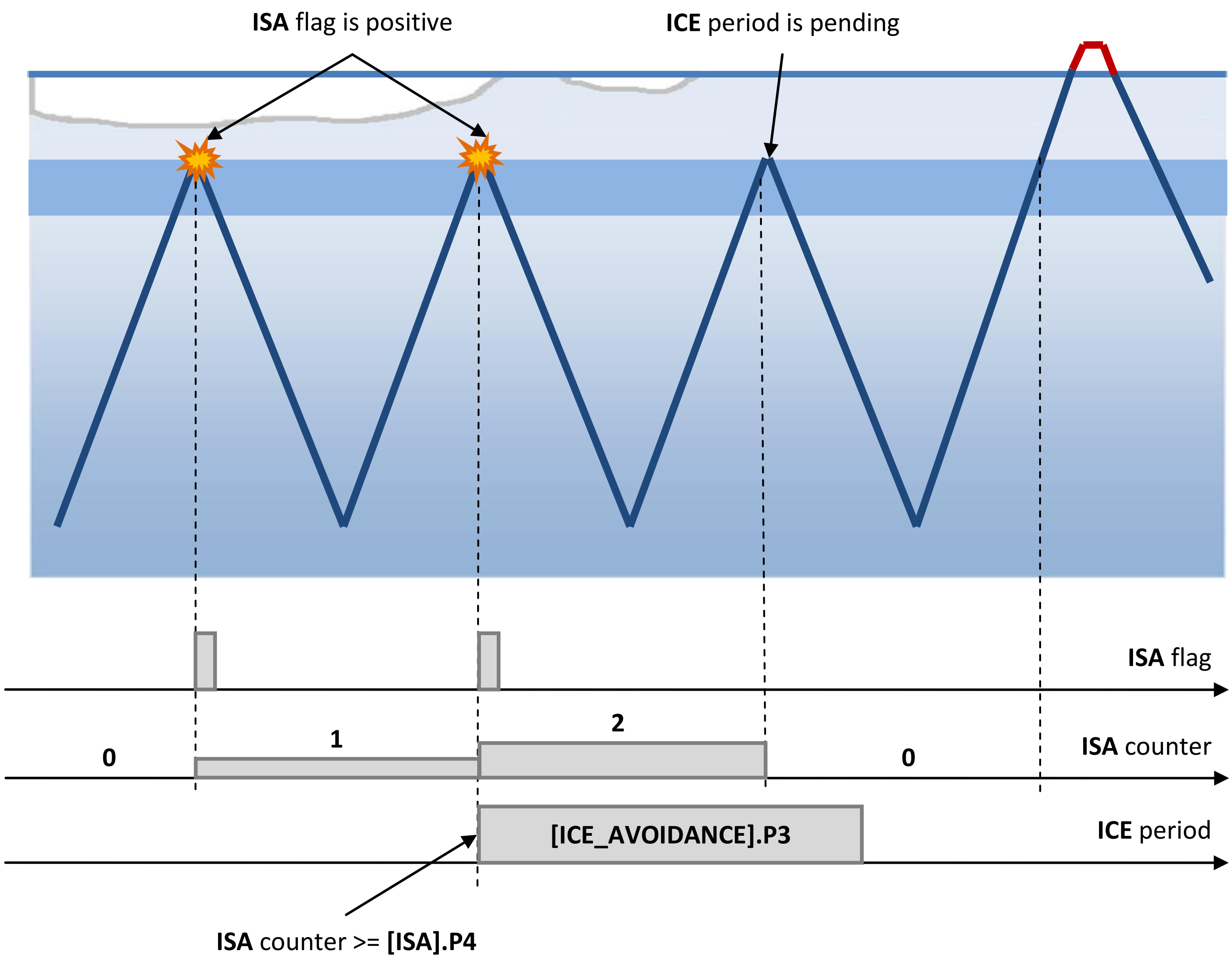
The idea behind the ice detection maintaining period is to postpone surface session for a predetermined number of days after the last ice detection. This delay allows time for the ice to break-up and the profiling float to find a new ice-free zone.



--- Figure 8. ICE period management ---

In the event that ice is detected by the ISA algorithm, a successive ISA detection counter is incremented to filter the information.

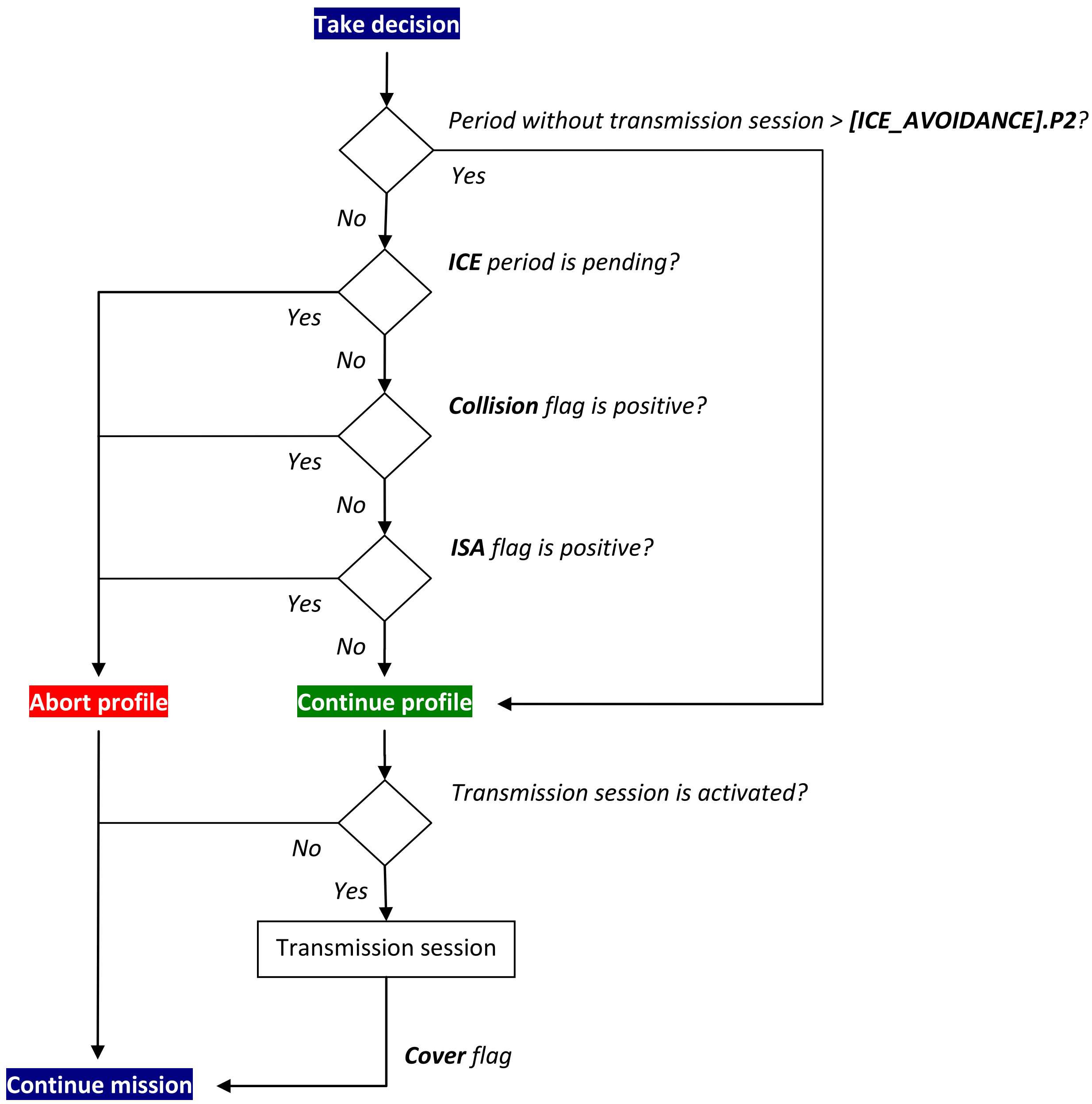
The counter threshold can be seasonally modified with script-programmed changes.



--- Figure 9. ISA counter vs. ICE period ---

Note: In case the ice-sensing algorithm is aborted by collision detection, the ISA flag is not set and the successive ISA detection counter is not changed.

3.7 Take decision: ice-avoidance algorithm

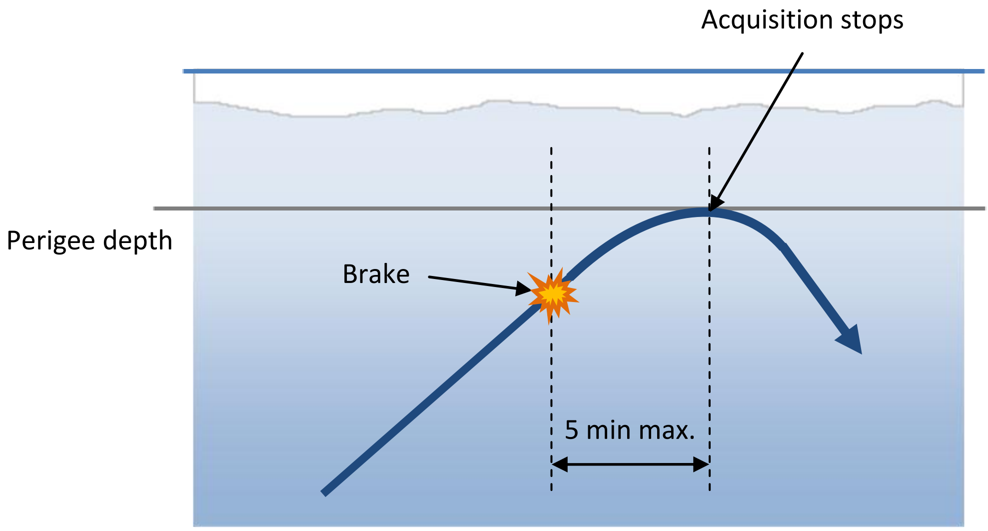


--- Figure 10. Ice-avoidance algorithm ---

3.8 Aborting a profile

Once the decision to abort a profile is taken, the float immediately reduces its buoyancy by braking.

The acquisition remains active until the detection of the ascent perigee (5-minutes time-out since the brake action).



--- Figure 11. Aborting profile ---

Note: For more details on braking settings refer to “33-16-048_Parameter_Set” manual section “special surface behaviours”.

4. Parameter setting

4.1 Related parameters

[SYSTEM]

No.	Comment	Limitation
0	“Ice avoidance” mission script	128 characters

[ICE_AVOIDANCE]

No.	Comment	Limitation
0	Enable/disable ice avoidance	[True/False]
1	Depth for "slow" start of ascent (dbar)	[100-500]
2	Maximum duration period without trying a transmission session (s)	[1-12] months
3	Systematic abort profile period after ISA detection (s)	[0-90] days
4	Systematic abort profile period after collision or cover detection (s)	[0-90] days

[ISA]

No.	Comment	Limitation
0	Enable/disable ISA detection	[True/False]
1	Collection starting depth (dbar)	[30-50]
2	Collection stopping depth (dbar)	[5-20]
3	Median temperature threshold (°C)	[-1.9,-1.0]
4	Successive detections counter threshold	[1-10]

[TECHNICAL]

No.	Comment	Limitation
15	Fixed volume of a pump action during ascent (cm3)	[1.0-30.0]
21	Deceleration during ascent (0 = none, 1 = low, 5 = high)	[0-5]
22	Braking power in ascent abortion (multiplies P15)	[1.0-4.0]

[ALARM]

No.	Comment	Limitation
10	Detection threshold for collision during ascent (cm3)	[100.0-2500.0]

[SECURITY]

No.	Comment	Limitation
2	Detection management method for snagging during ascent	2

[IRIDIUM_RUDICS]

No.	Comment	Limitation
8	Maximum duration of Iridium registration (s)	[600-3600 (1 hr)]

Note: For more details on parameters refer to “33-16-048_Parameter_Set” manual.

4.2 Using pre-programmed changes

Under-ice features can be seasonally controlled by using pre-programmed changes with the script file. Periods of time can be programmed by the user to manage:

- Ice periods during which there is a certainty of presence of ice
- Transition periods (i.e.: spring inhibition) where ice can be detected
- Non-ice period during which the float must try to reach the surface

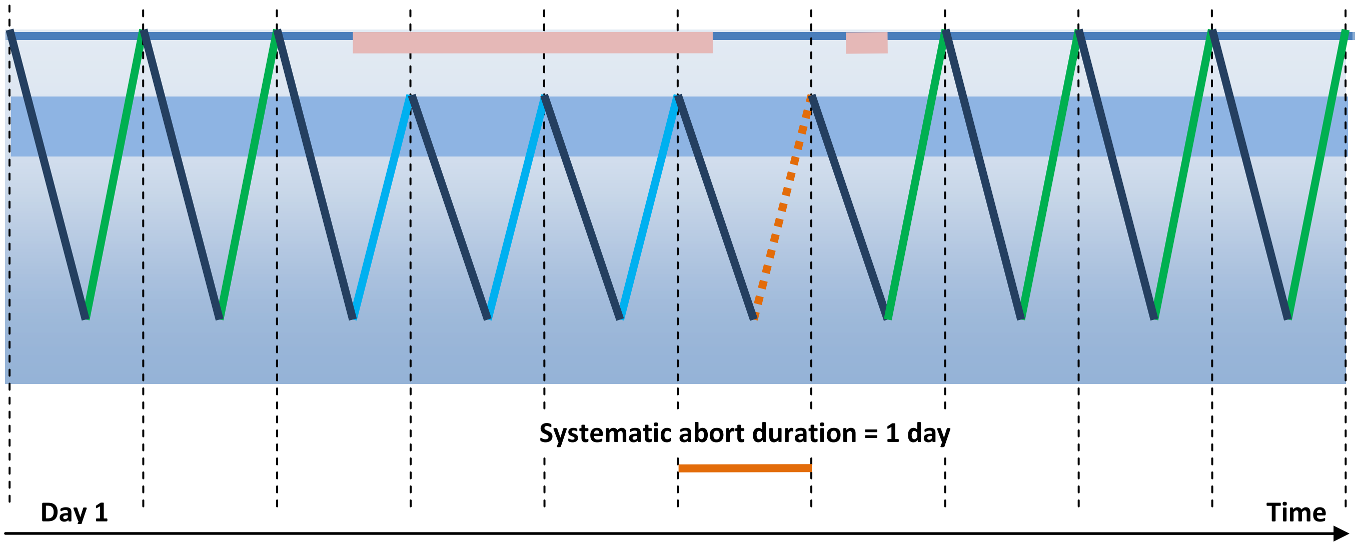
5. Appendices

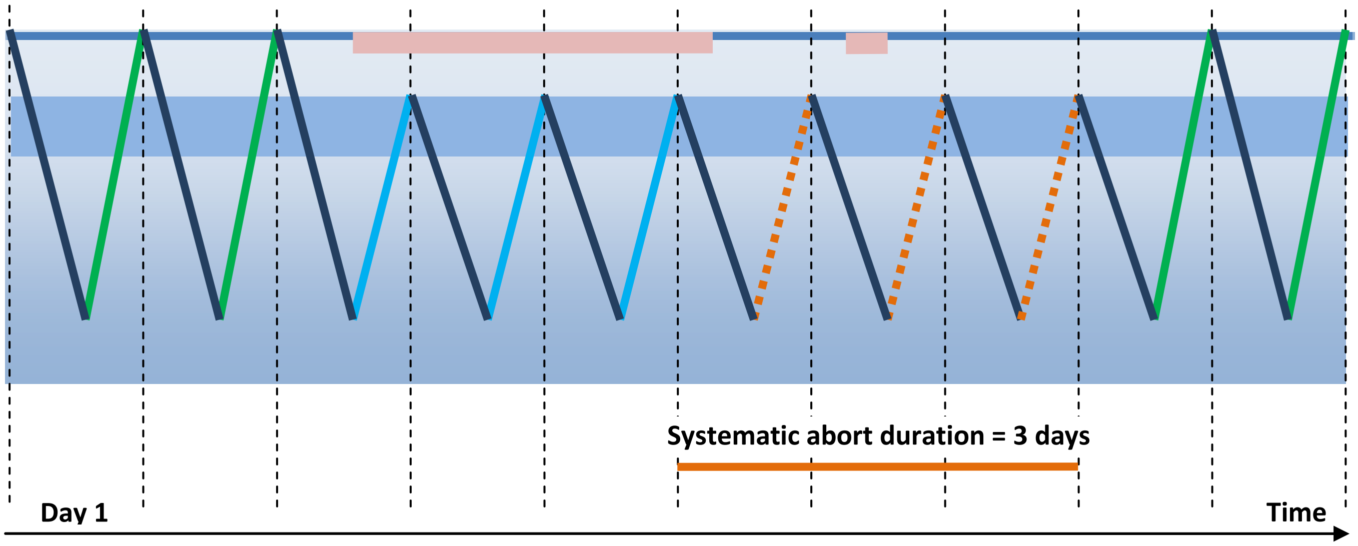
Examples below show under ice mechanisms and impacts of different settings applied to a 1 day profile mission:

- Represents the presence of sea ice at the surface
- Represents an ascent stage which finishes with a surface session (transmission success)
- Represents an ascent stage which finishes with an ice collision
- Represents an ascent stage aborted by ice detection mechanism (ISA flag)
- Represents an ascent stage aborted by ice persistence mechanism (ICE period)

5.1 Example 1: [ICE_AVOIDANCE].P3 parameter

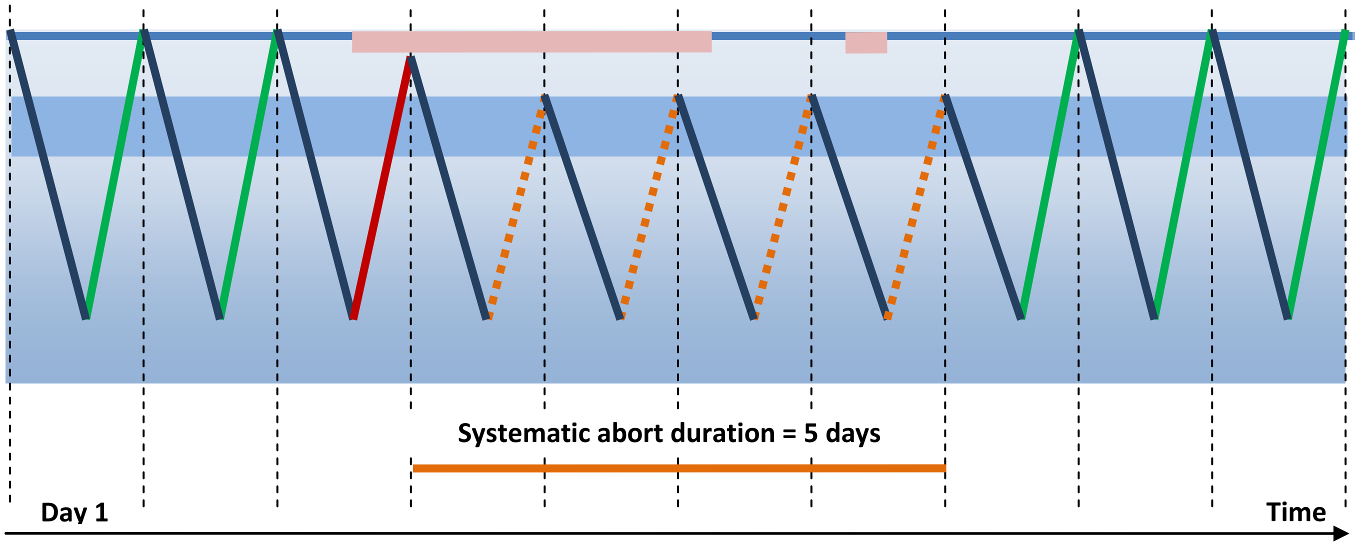
This parameter is used to maintain the ISA flag positive after the last detection has occurred.





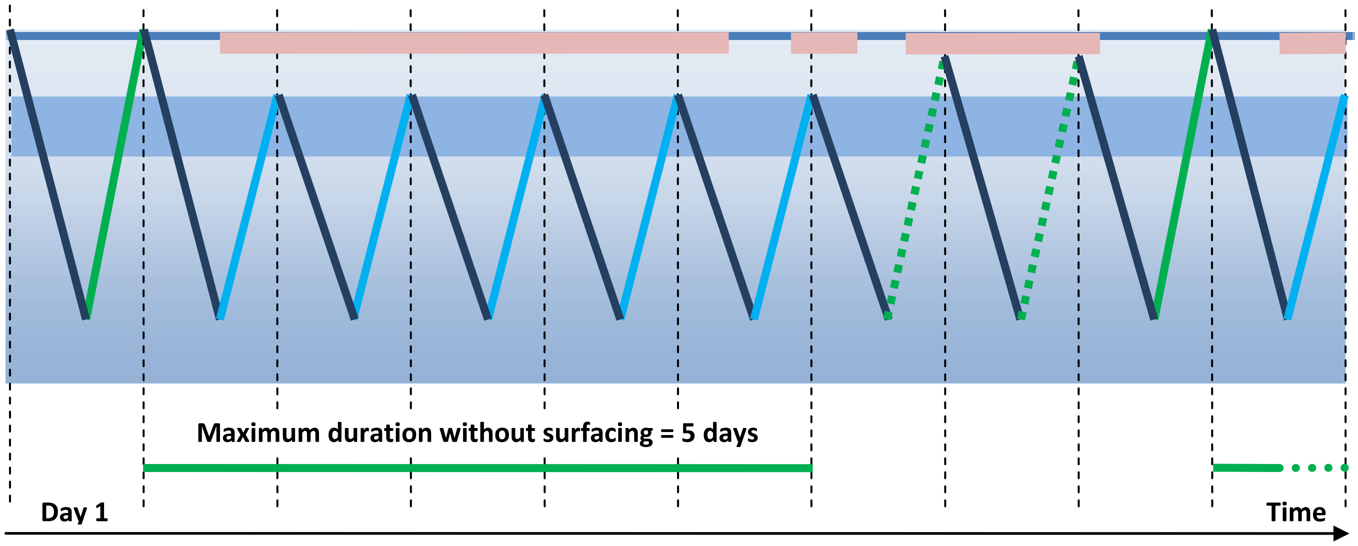
5.2 Example 2: [ICE_AVOIDANCE].P4 parameter

This parameter is used to maintain the collision (or cover) flag positive after the last collision (or satellite coverage) has occurred.



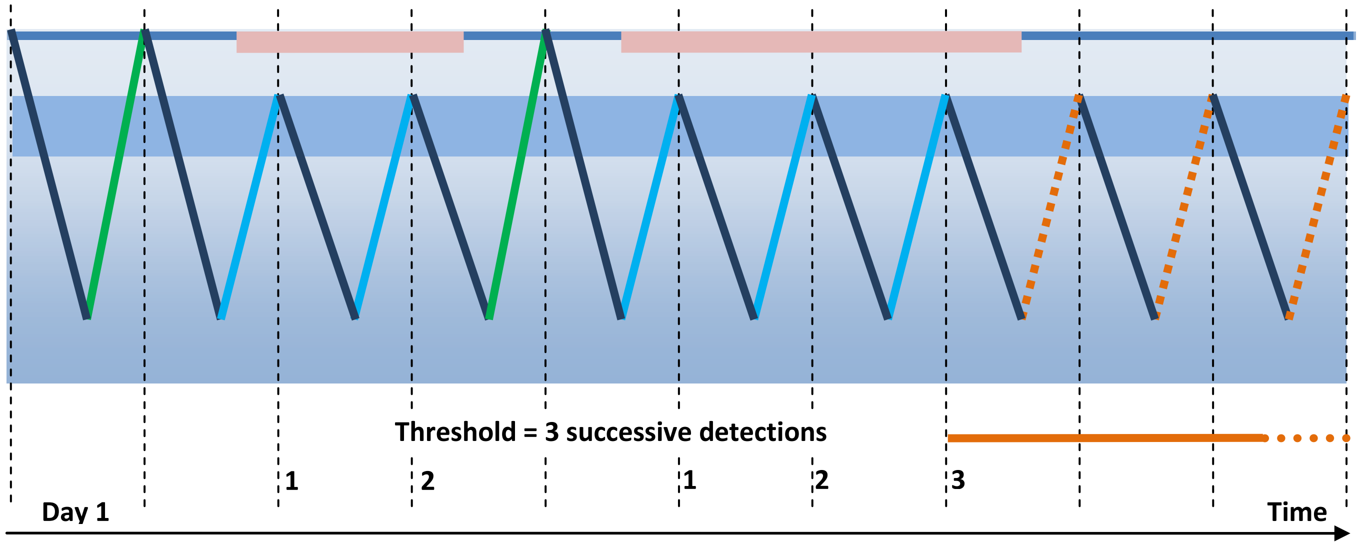
5.3 Example 3: [ICE_AVOIDANCE].P2 parameter

This parameter is used to force a surface session after a while without surfacing (even if ISA flag is positive or ICE period is in progress). The duration counter is restarted after an effective surfacing (with transmission success).



5.4 Example 4: [ISA].P4 parameter

This parameter is used to wait for successive ISA detections before applying the systematic abort duration.



nke Instrumentation
6, rue Gutenberg
ZI de Kerandré
56700 Hennebont
FRANCE
Phone: +33 (0)2 97 36 10 12

www.nke-instrumentation.com